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AIRSHIPS AND THE MODERN MILITARY

BY

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United States Army Reserve

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AIRSHIPS AND THE MODERN MILITARY

AN INDIVIDUAL STUDY PROJECT

by

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ABSTRACT

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The author, a dual-rated Master Army Aviator and a FAA certificated commercial airship pilot, takes a fresh look at potential application of the new generation airships to today's military missions. The paper presents a history of lighter-than-air development and provides some basic fundamental principles and theory of lighter-than-air flight. Application potential to current and projected military missions is then discussed with conclusions and recommendations offered.

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INTRODUCTION

One of the constant challenges before any military entity is how to continually improve Command, Control, Communications and Intelligence (C³I) capabilities and how to meet new missions that differ from routinely or historically assigned missions. An example is the entry of the U.S. Army into America's Drug War. This new mission has tasked planners to develop strategies for the Army's Total Force (the Active, National Guard and Reserve Components) to integrate its capabilities with the myriad of other agencies also involved in the drug war effort.

This paper presents the reader with up-to-date information on the potential application of state-of-the-art airships in accomplishing such critical requirements as C³I, surveillance and reconnaissance. Notwithstanding critical wartime missions such as the Desert Shield/Desert Storm operation, more focus by the U.S. taxpayer is anticipated on the contributions of a peacetime Army. Examples are search and rescue, border patrol, disaster relief and arms treaty verification.

A HISTORICAL REVIEW

Fort Sumter fell 46 years after Waterloo, but in that brief period scientists, chemists, engineers and adventurers introduced innovations unheard of by Napoleon. These included machinery that marked the rudimentary birth of air power.

The American War between the States, 1861-1865, made constant use of "the telegraph to quickly communicate with distant armies; railroads to transport troops and materials long distances and quickly; steamboats to convey them upstream and against tides; ironclad ships to render useless the wooden navies of the world; and to create one entirely new arm - or may we say pinion - to the art of war."¹ Most of these innovations were produced after Waterloo with one great exception - the balloon, the forerunner of modern aviation.

Almost 100 years before the U.S. Army took to the air, "Joseph and Etienne Montgolfier, French paper manufacturers, had discovered that heating air would make it lighter than the surrounding atmosphere and cause its container to rise."² On November 5, 1782, Joseph made the first demonstration of his idea by holding a silk bag inverted over a fire in the kitchen and, as a result, is credited with being the inventor of the lighter-than-air (LTA) balloon. King Louis XVI requested a demonstration of this discovery at Versailles. The Montgolfiers responded by constructing a very large and profusely ornamental paper balloon which required several months to build. Meanwhile, the first gas balloon (hydrogen) was constructed by the Robert brothers and

flown on August 27, 1783. The ascent began at the Champ de Mars in Paris. The balloon drifted 45 minutes and landed near Gonesse some 15 miles from the starting point. This was the first ascension of a hydrogen filled balloon. However, it transported neither person nor animal.

Some three weeks later the Montgolfiers prepared to launch their elaborately built hot air balloon. They had the additional goal of quelling the voices of pessimists who maintained that the atmosphere above the ground would not maintain life. So, on September 19, they sent their thermal balloon aloft from the outer court of the Royal Palace at Versailles with a sheep, a rooster and a duck suspended from it in a wicker cage. The balloon rose to an estimated 1,440 feet, drifted eight minutes and returned to earth in the Bois de Vincennes, some 10,200 feet from the launch point. "Though the voyage of this 'Montgolfier' balloon was shorter than that of the hydrogen-inflated 'Charliere,' it did more to pave the way for human ascensions, as the animals were quite unharmed by their unusual experience."³ It took almost four more weeks before a human went aloft. On October 15, 1783, Monsieur Francois Pilatre de Rozier won the distinction of being the first man to ascend in an aircraft, albeit a tethered Montgolfier balloon. Then on November 21, Pilatre and Marquis d'Arlandes completed a free flight of almost 25 miles from Paris over the Seine River. This flight took place in spite of the objection of the King who was willing to donate two criminals for such a perilous venture. Fortuitous for the United States was the fact that Benjamin Franklin was present to

witness this event. "In fact the affidavit that certified the flight bears his signature."4

The significance of Pilatre's ascension "was recognized by many of the luminaries of France and by visitors from other nations. Only five days after de Rozier's first tethered flight, Andre Giraud de Vilette wrote a letter to the Journal de Paris wherein he described ... a flight ... he made in the same balloon With this letter, he became the first man to outline the possible usefulness of the balloon in warfare."5

Soon afterwards, France became engulfed in a war of rebellion against Louis XVI and the idea of employing balloons in war was born. In 1794, "the French Republic became the first government in the world to officially recognize the impact of airpower."6 On April 2, the "1er Compagnie d'Aerostiers" was formed consisting of twenty-five specially trained airmen and officers outfitted in blue uniforms. Blue remains the color of most military aviation uniforms today. During the Battle of Maubeuge these airmen and their balloon, Entreprenant (Enterprise), accomplished the first wartime aerial reconnaissance in history, and by using megaphones, initiated the forerunner of today's airborne C3I mission. Other countries followed suit and, by the time the American Civil War broke out, war balloons had been used in Denmark, Sweden, Russia, Algeria and the Siege of Venice.

It did not take long for the early aeronauts to recognize that a dirigible balloon, that is a balloon that can be directed, turned or guided, with its own propulsion system, would be of

great advantage. In 1783, a young officer of the French Army Engineer Corps named Jean-Baptiste-Marie Meusnier submitted a paper to the French Academy on Aerostatics. His paper set forth the notion of powered and dirigible LTA flight and the concept of ballonets. Several attempts to put Meusnier's theory into practice failed until another engineer, Henri Gifford, became intrigued by the idea. He designed and built a steam powered "pressure airship with an envelope 144 feet long The engine delivered about three horsepower and weighed, with its boiler, about as much as two fair-sized men."⁷

On September 24, 1852, Gifford flew his "aerial steamer" at the Paris Hippodrome thus accomplishing man's first flight in a powered aircraft. Gifford's flight required the establishment of a second category of LTA craft, the dirigible balloon (today called an airship). The first category was assigned the title of free balloon. Both categories use either gas or hot air as a lifting medium. The next breakthrough came in 1895 when a German named "David Schwartz ...built the first rigid airship."⁸

"Ballooning antedates aviation proper by several centuries; it represents, indeed, man's first attempt to learn from the skies the plans of his enemies. In the Napoleonic wars France used balloonists against Austria, but so revolutionary was the procedure, and so out of keeping with the ideas of warfare then prevailing, that Austria treated all captured balloon observers as spies fit only for the ignominious death reserved as a penalty for illegitimate warfare."⁹

Even though LTA capability was fairly well known in France

and several other European countries many years prior to Napoleon's military exploits, it was not until the American Civil War that balloons were routinely employed by an armed force for military purposes. American ingenuity quickly rose to the occasion and, as a result, gas balloons were employed by both Union and Confederate forces throughout the Civil War for observation and C³I missions. This marked the birth of military aviation in the United States. After the close of the Civil War, U.S. Military Aviation progressed little for the next 40+ years as the War Department gave little or no thought to the continuation or improvement of aviation. The Signal Corps, which began its legal existence July 1, 1891 became the proponent for Army Aviation due primarily to the vision of BG Adolphus W. Greely, the Corps' first Commander. The balloon section he created in 1892 "marked the beginning of the first Military aeronautic organization in the United States Army."¹⁰

Between 1892 and 1898, several annual reports from BG Greely to the War Department "invited attention to the increasing efficiency of Military dirigible balloons operated by the first class Powers of Europe. He urged appropriations ... to make a start toward similar development of the new reconnaissance aid to armies in war"¹¹ Meanwhile, the Signal Corps successfully used balloons in the War with Spain at the Battle of San Juan Hill in 1898.

In February, 1906, two free balloon flights were conducted from the U.S. Military Academy reservation at West Point by pilots from the newly created Aero Club of America, a civil

ballooning organization. These two flights, and a third flight conducted on March 31, were accomplished ostensibly to attract the interest of the military authorities. Many of the cadets present for these ascensions acquired their first knowledge of aeronautics and later became pilots of the U.S. Army Air Corps.

The increasing number and use of military airships in Germany, France, England, Italy and Russia prompted the U.S. military to take a look at their potential use. In 1908, the Signal Corps contracted for "dirigible number one" which it took possession of in August at Fort Myer, VA. For the rest of that year and most of the next, the U.S. Army trained several pilots, including Lt. Richard B. Creecy, a U.S. Marine, to fly this, the first U.S. Military airship.

The U.S. Navy ordered its first aircraft on May 8, 1911 and marks that day as "the birthdate of U.S. Naval Aviation."¹² Within four years (June 1, 1915) the Navy contracted for its first airship. Both the Army and Navy developed viable missions for airships and balloons and by WWI, LTA craft played significant roles at home and abroad. The Army took the lead from France and Britain on the employment of spotter balloons (a tethered free balloon) used to track enemy movements, adjust artillery and assess battle damage, among other missions. The Army also used a fleet of airships for the U.S. coastal defense mission. The most notable U.S. Army airship was the non-rigid "TC-13." The TC-13 had every up-to-date feature including a sub-cloud observation car, fuel and water ballast tanks (either of which could be refilled during flight) and an enclosed gondola.

The TC-13 could "cover a distance of 1,000 miles at a speed of 65 m.p.h., 1,800 miles at 50 m.p.h. and can remain in the air for about 100 hours at a speed of 25 m.p.h.."13 The U.S. Navy entered WWI on April 6, 1917. Germany's U-2 submarine threat caused the Navy to develop missions for both categories of LTA craft in their inventory. Airships took on the mission of escorting surface ships. A specialized free balloon called a kite balloon was developed and assisted the airships in anti-submarine warfare (ASW) missions.

After WWI, the U.S. Army got out of the LTA business but the U.S. Navy proceeded to develop the military application of LTA craft. Most notable was the switch from hydrogen as a lifting medium to helium on December 1, 1921. This one step precluded the U.S. Navy fleet from experiencing a catastrophe such as the crash of the Hindenburg. In the 40 year history of rigid airships, many firsts were accomplished including, the "first-ever strategic bombers, long-range naval scouts and intercontinental passenger carriers."14 Other innovations included the ability to launch biplanes from, recover them to and hangar them onboard airships such as the USS Akron and the USS Macon. Several setbacks in the Navy's rigid airship program were experienced between 1921 and 1935 culminating with the loss of the USS Macon in February, 1935. The next five years could easily be called the nadir of LTA activity for the Navy which included the permanent cessation of all rigid airship activities. WWII erupted and with it a resurgence in LTA activity. The Navy's LTA fleet went from six non-rigid airships (blimps) to a

peak of over 200. The measure of their effectiveness as a force multiplier is highlighted by the fact that "only one of the Navy's 168 ocean-going blimps was destroyed by fire from an enemy submarine, and of the 89,000 ships escorted by anti-submarine blimps, none was sunk."¹⁵ After the completion of WWII, the US Navy's airship fleet drew down until, on June 28, 1961, the decision to discontinue the operation of LTA craft was made.

LTA PRINCIPLES AND AERODYNAMICS

The basic principle upon which all lighter-than-air vehicles operate was first stated by Archimedes, who lived from 287 to 212 B.C. When he thought of the principle, the well-known story goes, he leaped out of his bathtub and ran naked down the street shouting, 'Eureka!' People have often wondered what happened to Archimedes after he stopped running, but that would be the subject of another chapter. Archimedes' principle states that the lift on a body immersed in a fluid is equal to the weight of the fluid displaced.¹⁶

It took another 2,000 years after Archimedes presented the "naked truth" for a balloon to lift man into the air. Between Archimedes and the Montgolfiers, there were several other key principles discovered. "About 1250 A.D., the monk, Roger Bacon, suggested that the atmosphere has an upper surface and that a large hollow globe, wrought extremely thin in order to be as light as possible and filled with 'ethereal air or liquid fire,' would float on that surface like a boat on a pond."¹⁷ The 17th century marked several scientific advances such as the distinction between the various gases, the invention of the

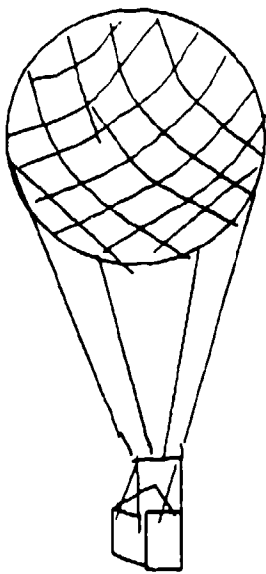
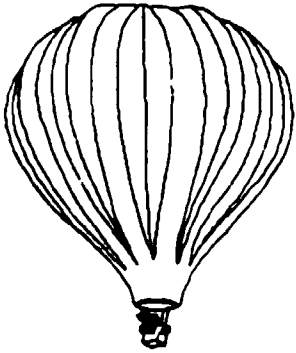
barometer and a published concept of a man-carrying airship.

The airship belongs, with its immediate forerunner, the free balloon, in the family of lighter-than-air craft. Airships are the outcome of an intense endeavor to endow the free balloon with the ability to be dirigible and have self-propulsion. Hence, the "dirigible balloon" of the late 18th century is today called an airship.

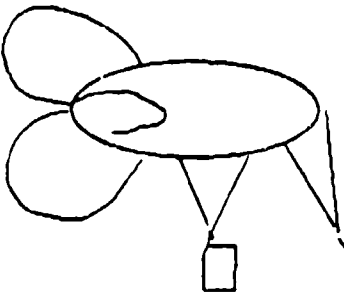
Within the category of free balloon there are two major subdivisions: gas and thermal (or hot air). Free balloons can be flown free "like the record breaking 6,761 statute mile flight of a hot air balloon from Japan to Canada just accomplished in January 1991"¹⁸ or tethered like the kite and barrage balloons of WWII.

The category of airship is typically divided into three major subdivisions which correspond to their structural design; rigid, semi-rigid and non-rigid (Figure 1). The rigid airship has a hull superstructure consisting of a skeletal metal framework which defines and keeps the overall shape of the airship. This framework is covered with a waterproof, but non-gas-tight fabric and then filled with several separate bags of gas fitted into separate compartments within the superstructure framework. These bags can be filled, emptied or changed independently. The engines are fitted directly to the rigid framework, typically on the sides or bottom of the hull, or they are attached to the gondola which is attached to the bottom of the hull. The Graf Zeppelin is an example of a rigid airship. This structure type, to date, has allowed for the largest and

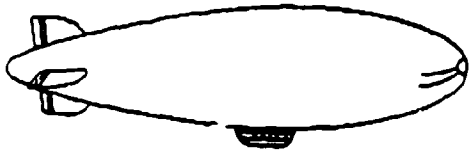
FREE BALLOON (HOT AIR)



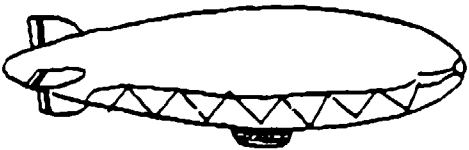
FREE BALLOON (GAS)



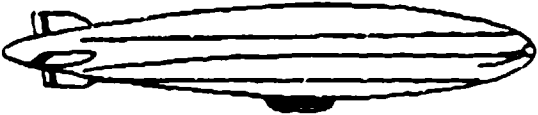
**KITE BALLOON
(TETHERED)**



NON-RIGID



SEMI-RIGID



RIGID

AIRSHIPS

FIG 1

fastest airships ever flown.

The non-rigid airship has no metal superstructure and relies on internal gas pressure to retain its hull shape. The hull is typically a fabric envelope treated to retain gas and is sewn in an elongated or cigar shape. The gondola is suspended at the bottom of the envelope by internal cables fastened to a cantenary curtain which is affixed to the top of the envelope. Battens are used to stiffen the nose of a non-rigid airship so that it will not "cave in" during forward flight in the high end of the speed envelope. Ballonets, which use ambient air, are incorporated within the gas envelope to allow for the expansion and contraction of the gas and to maintain an appropriate envelope pressure (Figure 2).

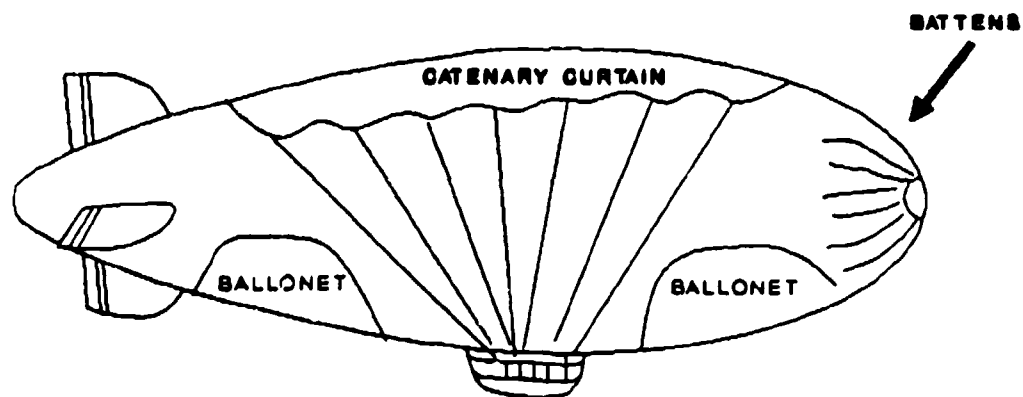
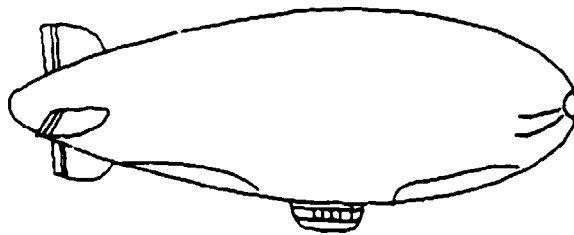


FIG 2 NON-RIGID AIR SHIP

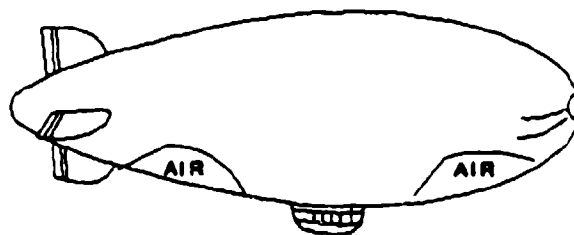
By maintaining an envelope pressure higher than the surrounding atmospheric pressure, the envelope will retain its proper hull shape. When the ballonets are full, they typically take up from 25-30% of the total envelope volume. As the airship climbs and the lifting gas expands, the ballonets valve off air to prevent the envelope from becoming over pressurized. Once the ballonets are completely empty, the airship has reached its pressure height and should not intentionally be flown any higher as the envelope will be subject to stress damage (Figure 3). The Good Year Blimp is probably the best known example of a non-rigid airship in the United States.

The semi-rigid airship is essentially a cross between the other two types. It mates a rigid keel to a non-rigid envelope and uses the keel to hold the gondola and engine(s). An example of a semi-rigid airship is the "Norge" which was the first aircraft of any kind to fly over the North Pole. It accomplished this feat in May, 1926.

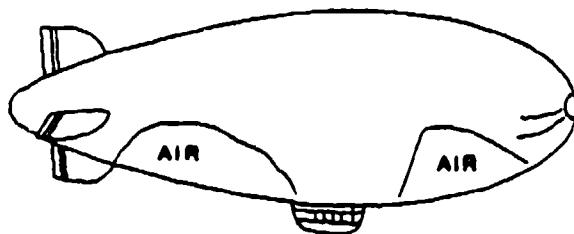
LTA craft derive their lift from an envelope or hull filled with either heated air or gas which is lighter than air. Until the twentieth century, the lifting medium of choice for airships was hydrogen gas. In 1921 the U.S. Navy converted to helium and, as a result of the catastrophic crash of the "Hindenburg" in May, 1937, the rest of the airship community worldwide followed suit. Helium is the second lightest element known, is 7.2 times lighter than air, is relatively cheap and easy to obtain and has 92.6% the lifting capacity of hydrogen. Another distinct advantage is that helium is completely inert and therefore will not support



PRESSURE HEIGHT (CEILING LIMIT)



INTERMEDIATE ALTITUDE



TAKE OFF CONDITION (BALLONETS FULL)

FIG 3 BALLONET OPERATIONS

combustion. Figure 4 gives a comparison of several of the lifting mediums that have been or are used in airships and some of their advantages and disadvantages.

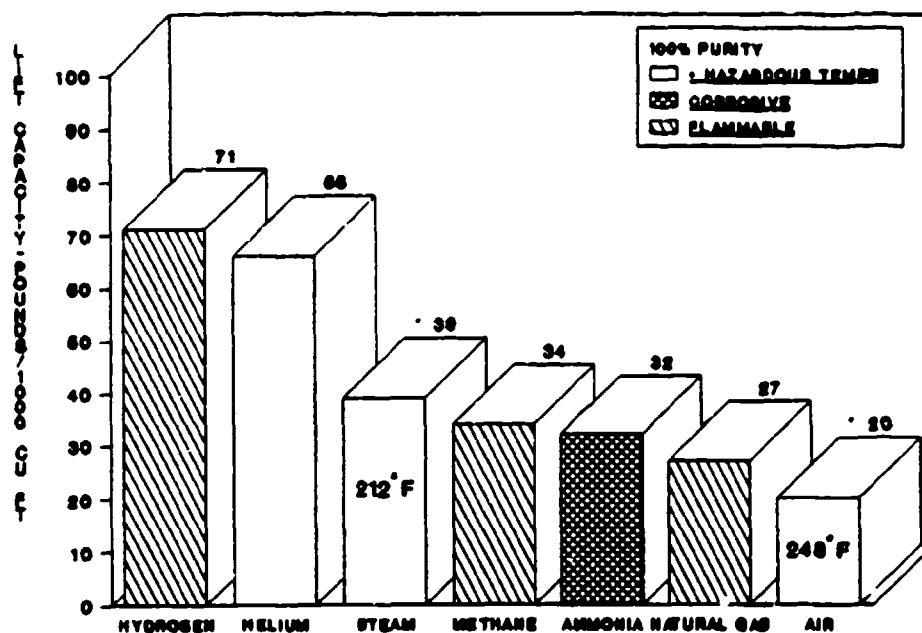


FIGURE 4 "LIFTING GASES COMPARISON"¹⁹

A discussion of some of the performance parameters is appropriate at this time, and they will all be directed towards the non-rigid airship. Safety is of paramount concern for the military and the statistics regarding this vital issue are very good news. Goodyear has operated a commercial fleet of non-rigid airships since 1925 and "over 1,000,000 passengers have been carried for a total of 9,000,000 miles without a single mishap."²⁰ Non-rigid airships are clearly inherently safe.

Speed is not the strong suit of an airship due to the very large hull size and the resulting high degree of induced drag. The typical speed range is 30-45 knots (34.5-46 m.p.h.) for the

smaller, 2 and 3 person airships and up to 90+ knots (103.5+ m.p.h.) for the largest non-rigids. This means that they can keep up with any conventional oceangoing surface vessel and any land vehicle such as the M1A1 tank.

Because of the limitations presented by gas expansion and changing temperatures, altitudes frequented by airships range from the surface to 10,000 ft above Mean Sea Level (MSL) with a pressure height ceiling of up to 14,000 ft MSL for the largest airships. Additionally, because the lifting gas is a fixed volume, the load lifting capability decreases with altitude.

Endurance has always been synonymous with airships. Fuel requirements for airship engines are low compared to other types of aircraft. Given that some airships can refuel without landing, great distances can be achieved. The only limitation appears to be pilot fatigue. "The U.S. Navy's ZPG-3 could operate over 100 hours without refueling and had a range of 3400 nautical miles when operating at 40 knots."²¹

Weather capabilities for airships is a primary consideration. Several of today's non-rigid airships are certified for IFR (Instrument Flight Rules) flight. They have state-of-the-art navigation equipment onboard and are capable of flying any instrument approach currently used or projected (with the exception of jet penetrations). Because of their slow speed capability, airships are able to equal or outperform all other types of aircraft in fog and low visibility.

Wind is of greater concern to and has greater impact on airship operations than most other aircraft. High winds present

a problem when moving airships either into or out of a fixed hangar facility. However, high winds (up to 80 knots) do not present a problem to airships on the mast in the open because of their ability to weathervane 360°. Sustained, steady or strong winds do not present a problem to airships in flight but they have a definite effect on ground speed and could make the difference as to whether a particular flight goes or cancels.

Precipitation such as rain, snow and ice can pose problems for airships but these can be more of a problem on the ground than in the air. Due to the large surface area of the hull, snow and ice can easily accumulate on the top of a moored airship. Several cases of landing gear failure due to exceeding design load factors have been recorded. A competent ground crew can preclude such a problem. Accumulation of inflight precipitation such as rain can degrade available lift because water weighs 8 lbs/gal. Dumping ballast may be required to maintain an appropriate amount of lift for the mission.

Severe weather is something to be avoided by all types of aircraft. While the airship may seem more vulnerable to severe weather than other types of aircraft, "the record of the U.S. Navy's non-rigid blimps shows that no airships of this type were lost due to structural failure as a result of poor weather."²² While it is true that no aircraft can perform its assigned mission in every type of weather, "the airship has demonstrated, through experience and extensive trials, that it can operate through extremes ranging from tropical storms to polar cold, blizzards and icing."²³

POTENTIAL MILITARY MISSIONS

"It has always been the lot of airships to suffer by comparison with aeroplanes. The prejudice of many people today is undoubtedly due to their illogical assumptions that, with aeroplanes at the peak of their development, airships are superfluous."²⁴ This statement, notwithstanding the fact that "aeroplane" technology has not yet really peaked, does typify the attitude of many military aviation decision makers, both past and present.

By the early 1960's, moreover, a change in programmatic strategy by the U.S. military began to favor the high-technology, fixed-wing aircraft that are dominant today. Through no fault of their own, airships gained a reputation for being a technology 'whose time had come and gone.' In fact, the extraordinary advances of the past twenty years in microelectronics technology (leading to more efficient radars), propulsion engineering, composite materials, and new fabrics make airships a technology whose time has finally come.²⁵

During the 1980's, the U.S. Navy conducted in-house analysis and, as a result, let contracts totaling \$600,000 for design feasibility studies of airships and \$300,000 for large airborne radar systems. "The goal was to develop a multi-functioned airship capable of AAW, AEW, ASUW, ASW, ECM, ESM, EW, JSTARS and C³I missions and capable of carrying AAAM missiles to interdict the cruise missiles in flight and kill air and surface hostile delivery platforms. Additionally, torpedoes would be carried to kill hostile subsurface missile launchers."²⁶

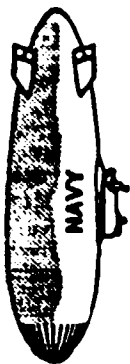
The confidence of the U.S. Navy, in both the possibility and

practicality of such an airship, was demonstrated when they initiated a \$200 million program dubbed the Operational Development Model (ODM) Airship Program. "On 5 June 1987, NAVAIR awarded the Westinghouse/Airship Industries consortium with a \$168.9 million firm fixed price contract to build and supply the ODM airship for evaluation by the U.S. Navy."²⁷ The consortium is building an ODM prototype, the "Sentinel 1000," which is a 353,100 ft³ envelope airship scheduled to fly in 1991.

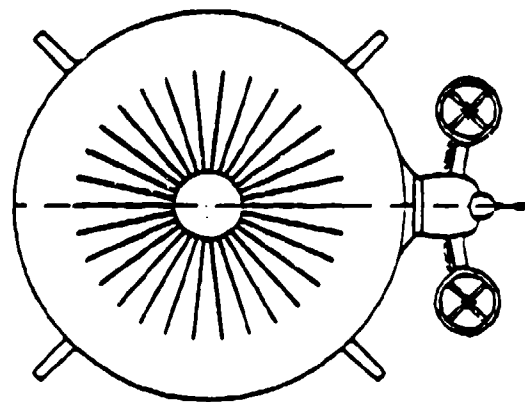
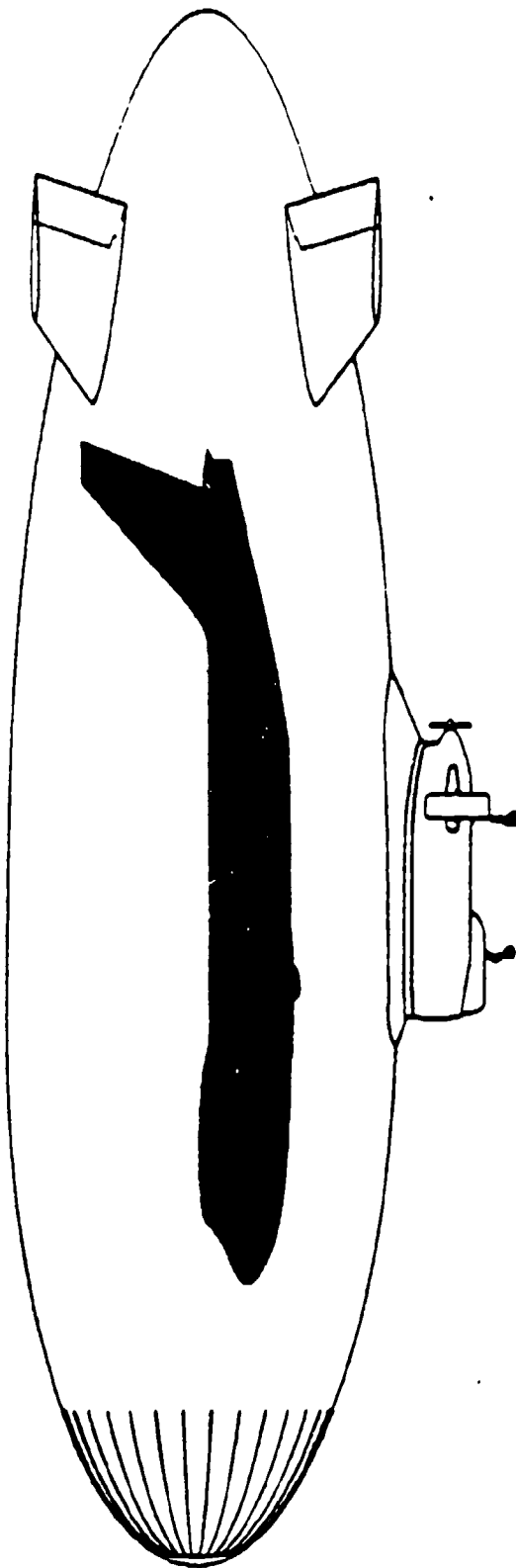
The goal of the U.S. Navy is the "Sentinel 5000," which is twice the length and seven times the volume of the Sentinel 1000. Projected performance characteristics and dimensions of the Sentinel 5000 are a 2.5 million ft³ envelope, with a length of 425 ft, a height of 152 ft, a cruise speed of 88 knots (101.2 m.p.h.), an operating altitude of up to 14,000 ft and an endurance of up to 60 hours. This airship would have a Maximum Structural Disposable Load (MSDL) of 65,000 lbs. The MSDL is "the difference between the maximum gross weight and the 'green ship' weight (empty weight ready to fly without mission equipment, usable fuel, furnishings or crew)."²⁸ Other key features of this Modern Airship Vehicle (MAV) are the use of "modern avionics and computer technology, non-metallic, radar transparent materials, a vectored thrust propulsion system and a fly-by-light control system that will not be affected by the high-energy radar pulses discharged by the ship's radar system."²⁹ It will be able to carry a crew of 15 in a triple decked, pressurized gondola. The comparative size of the "5000" (Navy designation YE2-2A) to a Boeing 747 is shown in Figure 5.



(U) YEZ-2A GENERAL ARRANGEMENT



UNCLASSIFIED



DIMENSIONS

LENGTH OVERALL	425 FEET
HEIGHT OVERALL	135 FEET
DIAMETER OF ENVELOPE	105 FEET
CAR LENGTH	79 FEET
CAR HEIGHT	24 FEET

FIG 5 SIZE COMPARISON³⁰

UNCLASSIFIED

U.S. ARMY APPLICATION

In view of the "coming of age" of MAVs, what are their potential applications for U.S. Army missions, both peacetime and wartime, present and future? The first issue to be addressed will be survivability since all the capability in the world will not mean much without survivability. There are several aspects to survivability of which two will be considered here: Hostile Environment and Crashworthiness.

With respect to the first issue, a MAV "could prove to be a difficult target for many of today's medium and long range radar guided anti-air missiles. One reason for this is the slow operating speeds and ability to hover, which makes it difficult for a missile or fighter jet radar to discriminate the airship from clutter using pulse doppler tracking."³¹ Secondly, MAVs "present a small radar and infrared signature due to the use of non-metallic composite materials and low powered propulsion systems which give off little heat."³² The little heat that is generated by the engine(s) is quickly cooled and dissipated by the propeller wash. Thirdly, MAVs "can utilize both passive and active measures to counter a threat. Passive measures could include onboard Electronic Support Measures (ESM) equipment and launchable decoys such as chaff. Active measures could consist of point defense gun and missile systems or even a long-range missile launching system."³³ Finally, the envelope of a MAV can be painted using camouflage patterns consistent with the terrain coloring in which the MAV will be flown to counter the

visual identification threat.

A potential drawback for the MAV in a hostile environment is its slow flight speeds when trying to evade enemy aircraft within visual range. For the purpose of this discussion, an assumption is made that the U.S. Army employment of MAVs would be well back from the FLOT. Therefore, they would not be subject to an enemy aircraft threat unless the U.S. or its allied forces did not enjoy air superiority.

Crashworthiness, on the other hand, has no apparent downside. As previously mentioned, MAVs will take full advantage of the latest technologies such as composites and plastics, side-stick controllers (joy sticks), fly-by-light controls and state-of-the-art, plastic-lined fabric envelopes. Because the flight speeds are low, impact damage is proportionately reduced. The large gas bag or envelope provides incredible force attenuation which, when striking the ground nose or tail first, reduces impact forces to that of a gentle shove. Because the gas pressure in the envelope is so low (0.5 - 1.0% of ambient), the MAV envelope can take several hits from small arms and still be safely flown. It is estimated that "large holes, approximately 5 to 15 feet in diameter, would require that the airship abort the mission and return to base for immediate repair. Even with a hole this size, several hours could pass before the event would elevate into a critical situation."³⁴

A clear indication of their inherent safety and crashworthiness is the established safety record of non-rigid airships. The amazing safety record accumulated by Goodyear has

already been mentioned (page 15). U.S. military records on airship safety are also impressive. "In over 70 years of operation, which includes active service in two world wars, fewer than fifty deaths are associated with this craft."³⁵ Even though existing data strongly suggests that MAVs can survive hostile environments, a computer model could easily be developed to verify hostile environment survivability potential.

What about capabilities? Potential wartime missions for a small (40,000 - 60,000 ft³ envelope) MAV include most aspects of C³I. One of the greatest advantages for a commander on a fluid battlefield is the availability of real-time information. MAVs have the potential to accomplish this more thoroughly than any other present day, airborne platform. MAVs could easily fulfill the role of the utility helicopter "C and C ship" with radio, cellular and TV relay capability as well as over-the-horizon (OTH) communications. On-station time for smaller MAVs is typically 8-10 hours which is more than three times that of helicopters. In addition to microwave up and down links and onboard, large-aperture radars (which have better aspect than satellite radars), MAVs could provide the Army Intelligence community with JSTARS type information. Commanders could benefit from realtime information in support or maneuvers down to the platoon level. Because of MAVs high mobility, day and night, all-weather flight capability, long endurance and low and slow flight regime, rear area security and damage assessment also become viable missions. It is interesting to note that all these capabilities come "cheap" as "LTA craft cost from 1/5 to 1/7 that

of heavier-than-air craft."36

Potential peacetime missions may even be more attractive to U.S. Army decision makers. As fiscal constraints continue to manifest themselves in the 1990's, U.S. Army planners must find innovative ways to meet both present and future peacetime missions. Part of the "peace dividend" notion is an expectancy by the U.S. taxpayer for more focus on domestic issues. A direct result of the Federal Government's emphasis in this area is the U.S. Army's entry into the drug war and other formerly "nonmilitary" missions.

MAVs have a great potential to help the U.S. Army meet peacetime missions both at home and abroad. Capabilities such as C³I and JSTARS for National Training Center (NTC) exercises, arms treaty verification, search and rescue, border patrol, convoy control, communications relay, littoral surveillance, pollution monitoring, fire watch patrol, civil disturbance, disaster preparedness and assessment, and a platform to use as a research and development testbed.

For NTC exercises, MAVs could also provide an aerial video of the entire battlefield for debriefing and post exercise critique. The senior or coordinating umpire would have a complete look at "the big picture" which would enhance realism and safety.

If and when arms control treaty verification becomes a reality, MAVs have the potential to be the most economical and functional platform from which to accomplish this mission. With long endurance, low cost and low maintenance added to the

information gathering capabilities of MAVs, this mission becomes a natural.

Search and rescue continues to be a vital role for the Army. Because the MAV is an all-weather, slow speed, long endurance platform with the ability to hover, this mission can easily be performed at considerable savings when compared to other types of aircraft.

The scourge of illegal drugs on the United States has caused the Federal Government to mobilize all available resources to combat it. The U.S. Army has been given a portion of the mission and MAVs could prove to be the most practical and effective platform from which to conduct border patrol and other drug war related tasks.

Convoy control continues to be both necessary and, when performed by helicopters or other aircraft, costly. MAVs appear to be a cost effective alternative that can match both the speed and endurance of convoys on land or sea.

Littoral and maritime surveillance from the Gulf of Mexico to the Gulf of Arabia is a mission well-suited for MAVs. There is an abundance of airborne maritime radars that can be fitted to small airships. In addition to MAVs maneuverability, mobility and endurance, their low speed reduces radar clutter which enhances target detection.

Pollution detection and monitoring continues to increase in its importance. MAVs could easily be fitted with telemetry that would identify airborne pollution otherwise unnoticed. Day/night, all-weather capability, extended range and minimum

maintenance requirements make the MAV ideal for this mission.

Fire watch or patrol is a very similar mission. MAVs could be used in an early detection role. Several times over the past few years, U.S. Army soldiers have been pressed into service fighting forest fires in our national forests. The presence of a MAV could enhance the coordination and continuity of effort on such a critical mission.

When France celebrated its bicentennial in 1989, an airship was used by the chief of security as the primary airborne command post for Paris. It was flown day and night, in all weather, and provided 24 hour C³I for those responsible for the safety of both French and visiting dignitaries. It was an unqualified success.

After natural disasters such as tornadoes and hurricanes, disaster assessment is always a critical and time sensitive requirement. The TV surveillance, communications relay and mobility make the MAV an essential contributor to disaster recovery. Also, the MAV's ability to hover provides for spontaneous rescue.

Research and development costs continue to skyrocket. The MAV has the potential to provide a virtually vibration free airborne testbed at a fraction of the cost of heavier-than-air platforms. This could prove to be a boon to the entire Department of Defense research and development community.

Other government agencies have expressed interest for similar missions and additional missions such as fisheries, ocean current mapping, aerosol dispersion studies, and crowd control

for presidential inaugurations, etc. States have expressed interest for fish and game management, monitoring ice flows and tracking medical waste floating from New York.

One final issue is: "Why airships rather than aerostats?" Two large drawbacks immediately reduce the viability of aerostats in either peacetime or hostile environments. First, because they are tethered, aerostats become a hazard to navigation (especially at night). With helicopter and tactical jet aircraft attempting to operate in the same airspace, this would be unacceptable. Secondly, their fixed position would subject them to high targetability and give away ground positions. Clearly a highly mobile, manned airship would better serve military requirements.

CONCLUSIONS AND RECOMMENDATIONS

Modern airships can clearly perform well as a C3I platform. "Based on extensive use in both civil and military operations, the non-rigid airship has proven itself to be a highly capable platform in terms of safety and reliability. Its ability to carry large payloads, long endurance and stable, vibration free environment provides an ideal platform to support C3 systems and personnel for extended periods."³⁷ As with any new acquisition, once "a commander has use of a system that provides him greater capability to employ his forces, he will view that system as indispensable and will demand that the system be given the budgeting priority that he feels it deserves."³⁸

Because the resurgence of airships with updated technology

has already happened, research and development costs for the U.S. Army would be absolutely minimal. The U.S. Navy's cost/benefit data is very good news, especially in view of the shrinking military budget.

There are limitations associated with MAVs of which speed and altitude are the most noticeable. It has been determined, however, that slow flight speeds may, indeed, be a distinct advantage. High altitude reconnaissance is definitely out of the question. The most serious detractor from the acquisition of MAVs for the U.S. Army, it seems, will be skepticism. Many will feel that airships would be a step backward rather than viewing them as a technologically advanced, affordable addition to the commander's pool of resources.

Based on the research for this study, and several other current studies, the following recommendations are offered: First, the U.S. Army should appoint a study group to fully explore the merits of accomplishing present and future peace and wartime mission with MAVs. TRADOC needs to be brought into the loop and perhaps a joint venture with the U.S. Navy would be in order. Secondly, serious consideration should be given to acquiring one or two smaller MAVs and running the appropriate testing to validate capabilities. Off-the-shelf, 42,000 ft³, two-man airships with ancillary gear are available for \$600,000. Finally, as the defense budget continues to shrink, the U.S. Army should set parochialism aside and look towards the MAV as a significantly cheaper and a potentially more capable alternative to current aircraft platforms for the Army of the 21st Century.

GLOSSARY

AAAM: Advanced Air-to-Air Missile.

AAW: Anti-Air Warfare.

Aeronaut: A pilot or navigator of a balloon or lighter-than-air craft.

Aerostat: A tethered, unmanned, gas filled LTA craft deriving its lift from the buoyancy of ambient air rather than from aerodynamic motion.

Aerostatics: The science of gases in equilibrium and of the equilibrium of balloons or aircraft under changing atmospheric flight conditions.

AEW: Airborne Early Warning.

Airship: A lighter-than-air craft that is steerable and powered.

Ambient: Surrounding.

ASUW: Anti-Surface Warfare.

ASW: Anti-Submarine Warfare.

Ballonet: A separate bag inside the envelope in most non-rigid and semi-rigid airships which, by means of a blower and/or ram air, can be filled with ambient air to maintain the proper pressure in the envelope thereby keeping the envelope fully expanded. The ballonet is also fitted with an exhaust valve to allow venting of ambient air thus allowing for gas expansion and the prevention of an envelope overpressure condition.

Barrage Balloon: A small spherical captive balloon raised as a protection against airplanes.

Battens: A light piece of wood or metal used for stiffening the nose or other parts of airships or non-spherical balloons.

Blimp: A non-rigid airship.

Buoyant Lift: The lifting of the airship by gas alone.

C³I: Command, Control, Communications and Intelligence.

Captive Balloon: A lighter-than-air craft with no propulsion means held to a point on the ground by tethering or mooring.

Catenary Curtain: A curtain-type support used with suspension cables in the envelope of a non-rigid airship.

Dirigible: 1. The ability to direct, turn or guide. Steerable, maneuverable. 2. Often used to refer to a rigid airship.

ECM: Electronic Countermeasures.

Equilibrium: That point when lift equals weight and the balloon or airship is neither climbing nor descending.

ESM: Electronic Surveillance Measures.

EW: Early Warning.

FLOT: Forward Line of Own Troops.

Fly-By-Light: A method of controlling the maneuvering surfaces of an airship using fiber optics and electro-mechanical servos.

Fly-By-Wire: A method of controlling the maneuvering surfaces of an airship using a "joy stick" connected to electro-mechanical servos by electrical wire thus eliminating the need for cables and pulleys.

Free Balloon: A lighter-than-air craft with no propulsion means, that is not moored or tethered.

Gas Balloon: A lighter-than-air craft with no propulsion means, that uses gas as its lifting medium.

Gondola: Generic name for any car suspended below an airship, possibly derived from the fact that the early zeppelin gondolas were not only shaped like open boats, but were intended to float on the water.

JSTARS: Joint Surveillance and Target Attack Radar System.

Kite Balloon: A captive balloon having tail cups, lobes or fins.

LTA: Lighter-Than-Air.

MAV: Modern Airship Vehicle.

MSL: Mean sea level.

Non-Rigid Airship: A pressure airship whose elongated gas bag or envelope shape is maintained by gas pressure.

Observation Balloon: Military captive balloons for observation use.

OTH: Over-The-Horizon.

Pressure Height: For a non-rigid or a semi-rigid airship, is the height at which the ballonets become completely emptied of ambient air and the envelope completely filled with gas, which is

also determined by the percentage of gas fullness at the surface and atmospheric conditions such as temperature and humidity.

Superheat: The difference in temperature between the gas inside an LTA envelope and the ambient air outside the envelope.

Thermal Balloon: A balloon or airship that gains its lift from heated air; often referred to as "Hot Air."

TRADOC: Training and Doctrine Command.

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